Towards improving convection parameterization and the MJO in next-generation climate models: Project overview and preliminary results

NOAA MAPP Webinar 11-08-2011

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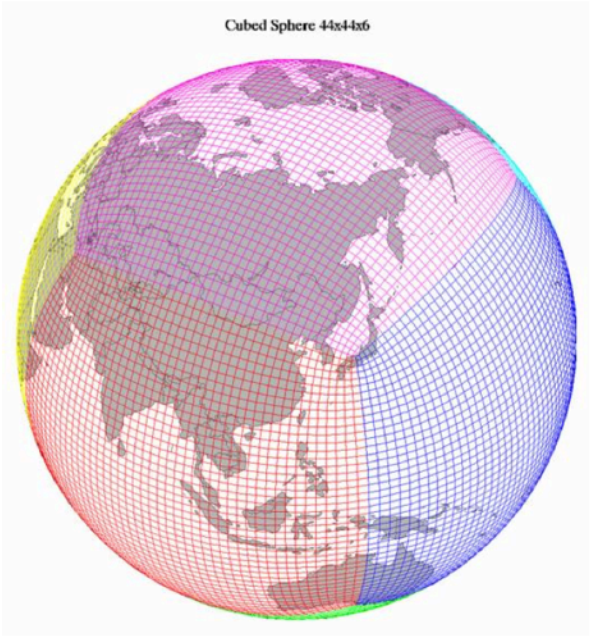
Bill Putman (NASA/GSFC)
Ming Zhao (UCAR/GFDL)

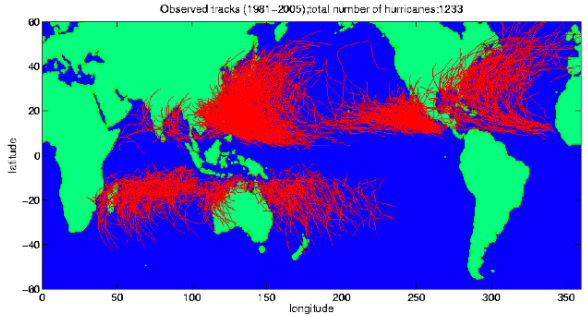
Motivation

Running global models with 10-20-km grid spacing (i.e., just sufficient for resolving tropical storms) is now feasible for making near-term (~20-yr) climate projections

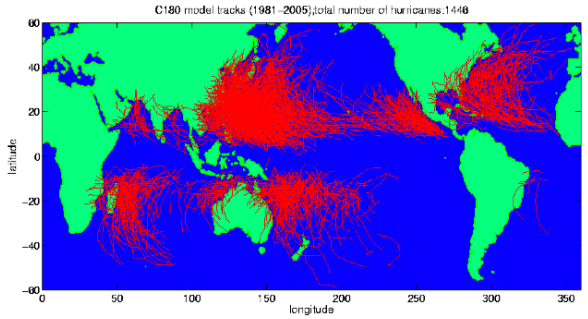
HiRAM at GFDL



Observed cyclone tracks: 1981-2005



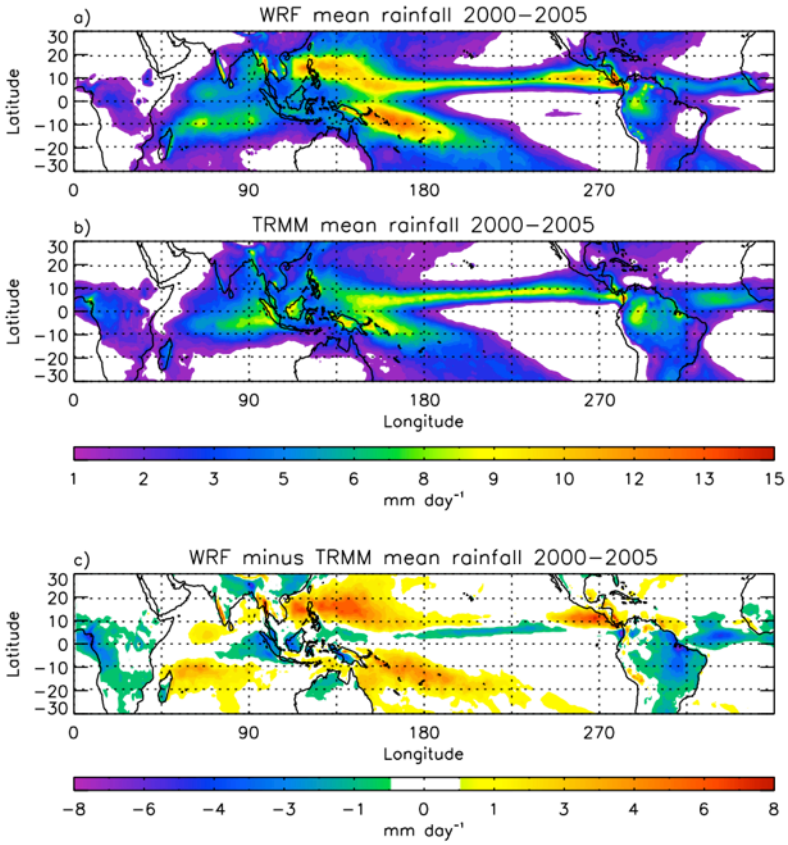
Simulated tracks: 1981-2005 (C180 model)

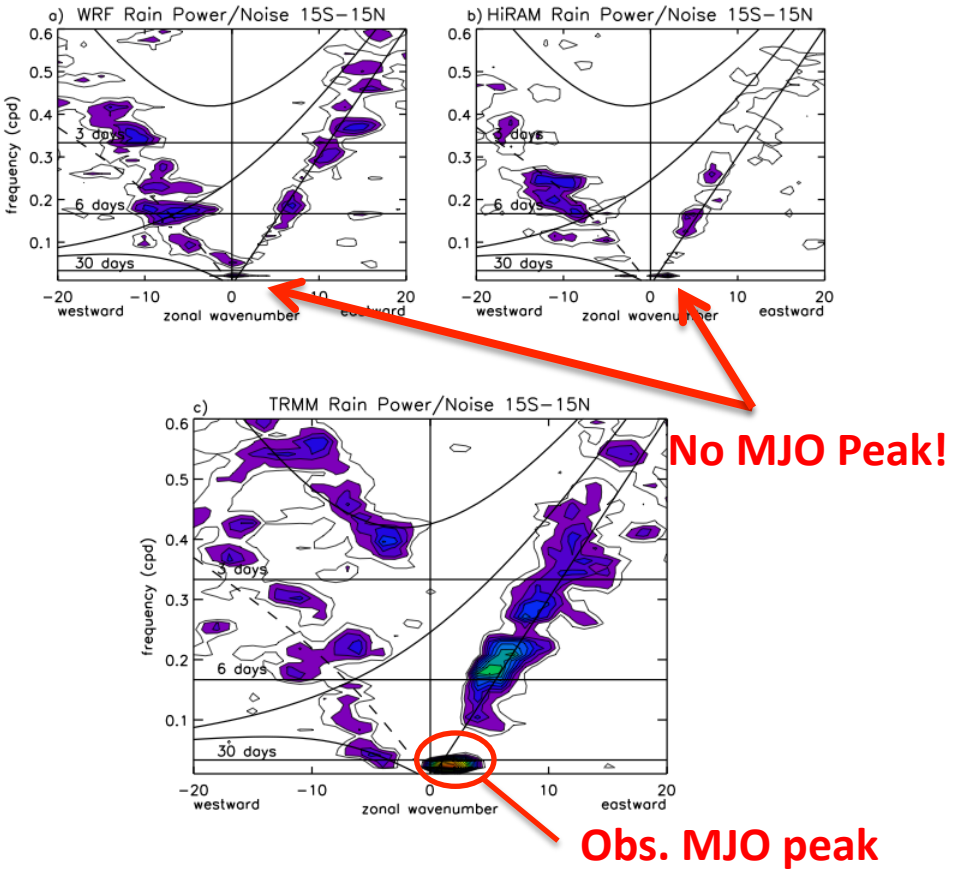


← One realization

Motivation (cont.)

However: Despite clear progress, the problem of mean-state biases and poor simulation of tropical transients still remains



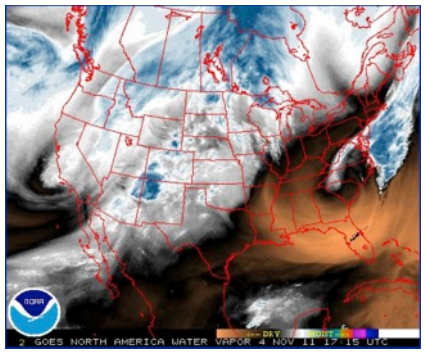


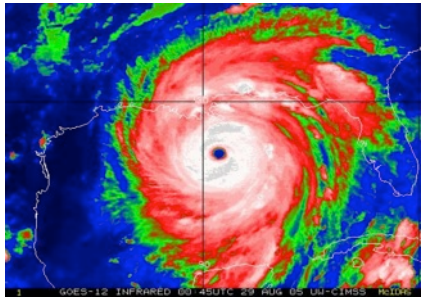
Motivation (cont.)

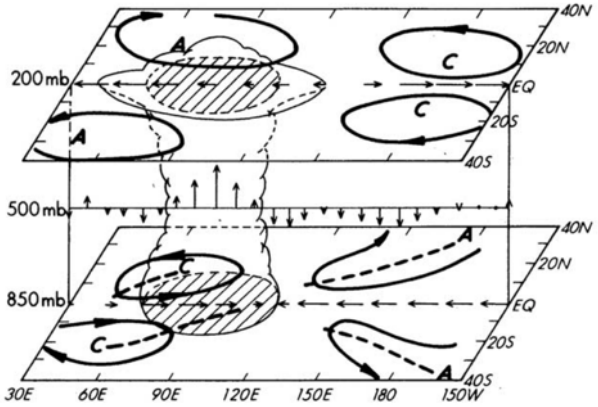
Capturing the MJO in global models is essential because:

MJO

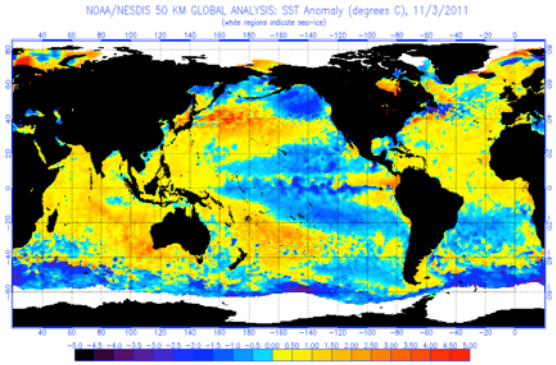
Weather

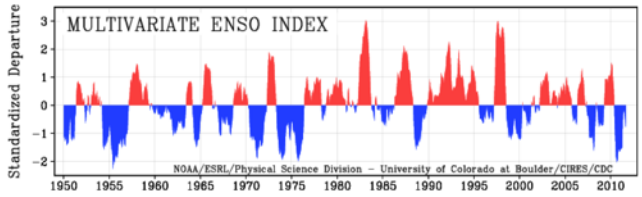






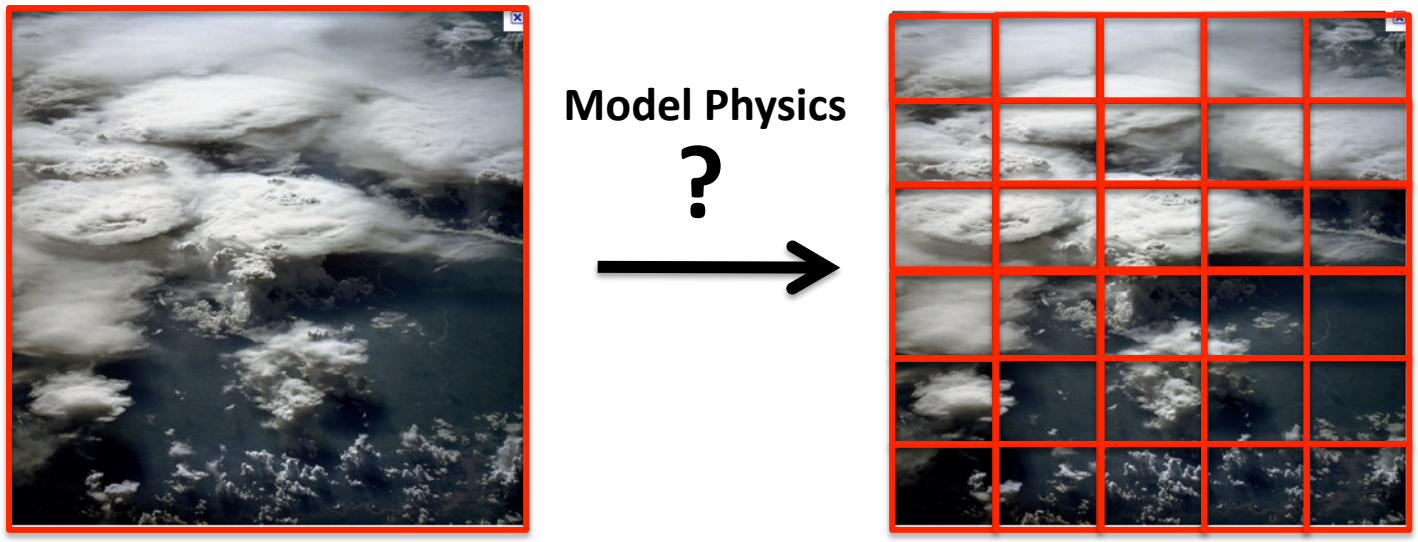
Climate





Basic Problem

The missing MJO highlights a key unresolved issue in the development of next-generation climate models:



Traditional model grid box with scale separation

Next-generation model with **partly** resolved convection

Research objective and questions

Objective: **Assess and optimize the performance of several different high-resolution global/regional models in simulating an individual MJO event during the 2009 Year of Tropical Convection**

Questions:

1) How does model performance change as horizontal grid spacing is systematically decreased from 50 to 5 km?

2) How does performance at a given horizontal resolution depend on model physics (parameterization of convection and microphysics)?

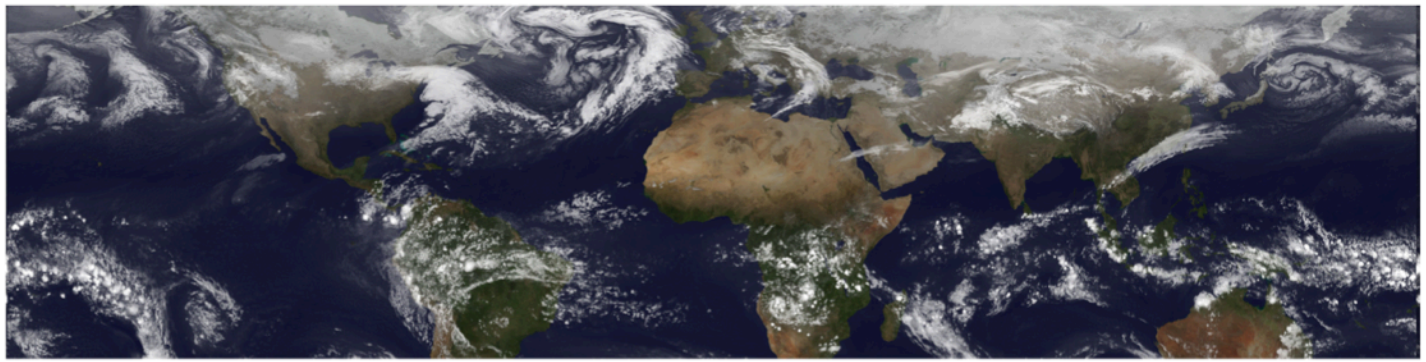
Models and Personnel

The project is a collaborative effort among several different research centers involving the use of 4 different state-of-the-art models:

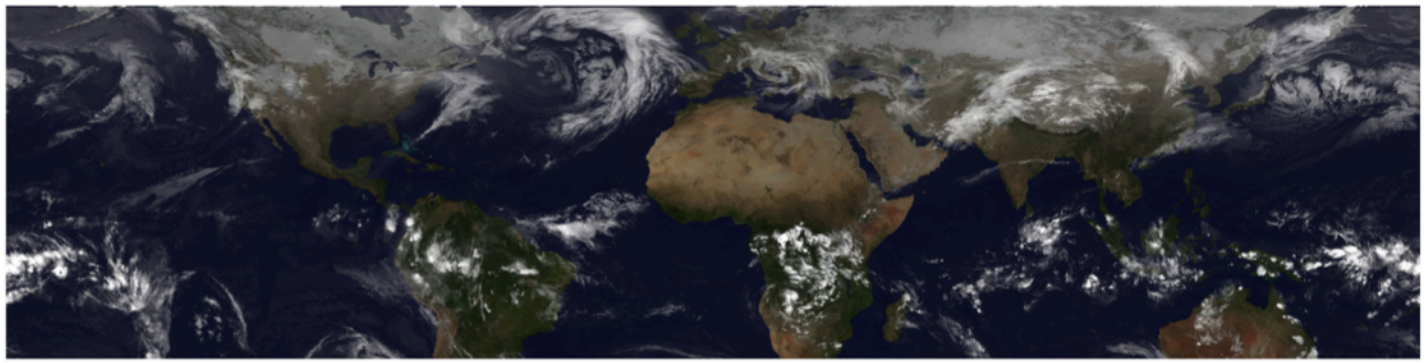
Model	Developer/User	Institution
WRF-ARW	Stefan Tulich	CU/CIRES-NOAA/ESRL
CAM5	Julio Bacmeister	NCAR/CGD
GEOS-5	Bill Putman	NASA/GSFC
HiRAM	Ming Zhao	NOAA/GFDL

These models are already being run at high resolution with promising results

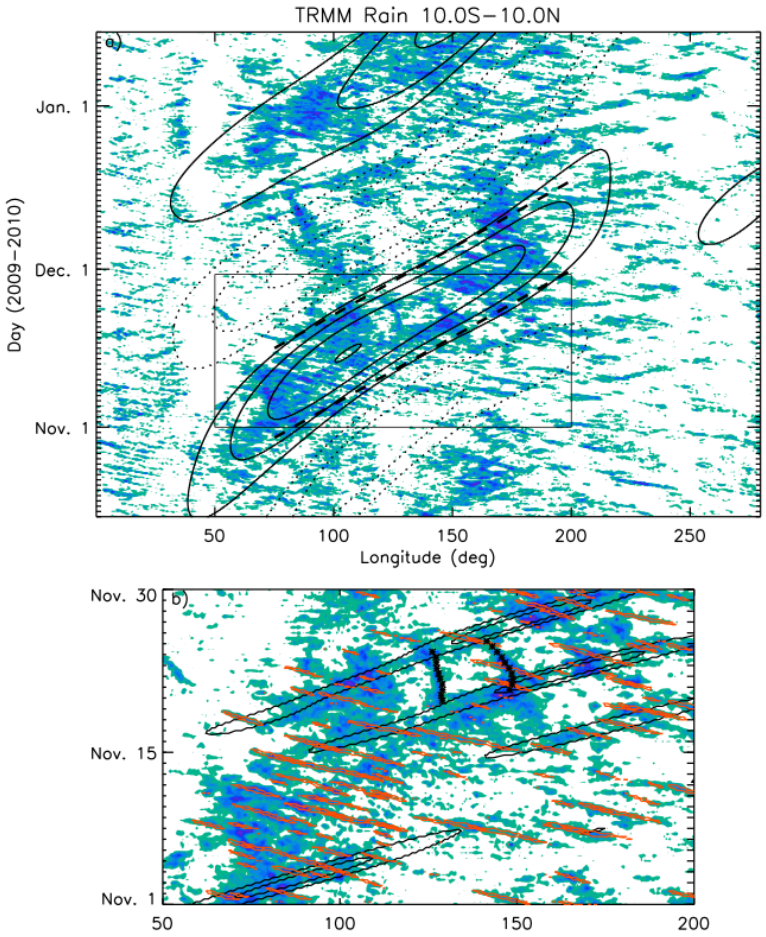
a) GEOS-5 Simulated Cloudiness (Feb. 6, 2010)

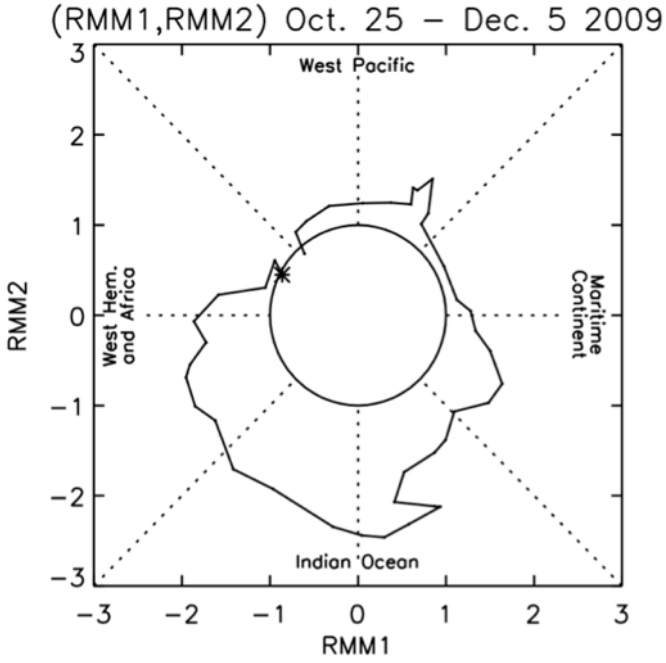


b) GOES Observed Cloudiness (Feb. 6, 2010)

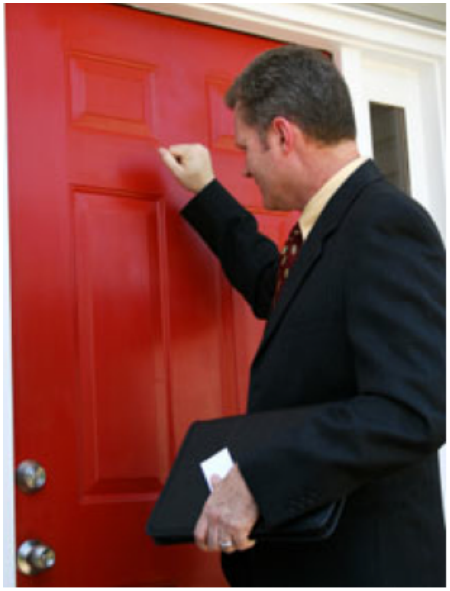


The 2009-YOTC MJO





Current Project Status: Spinning Up



Team members are still waiting to get accounts on GAEA…

So Julio will talk about some preliminary work that is already Informing the project

CAM5 Results

Tropical cyclones in CAM5

Sensitivity of simulation to convection parameterization

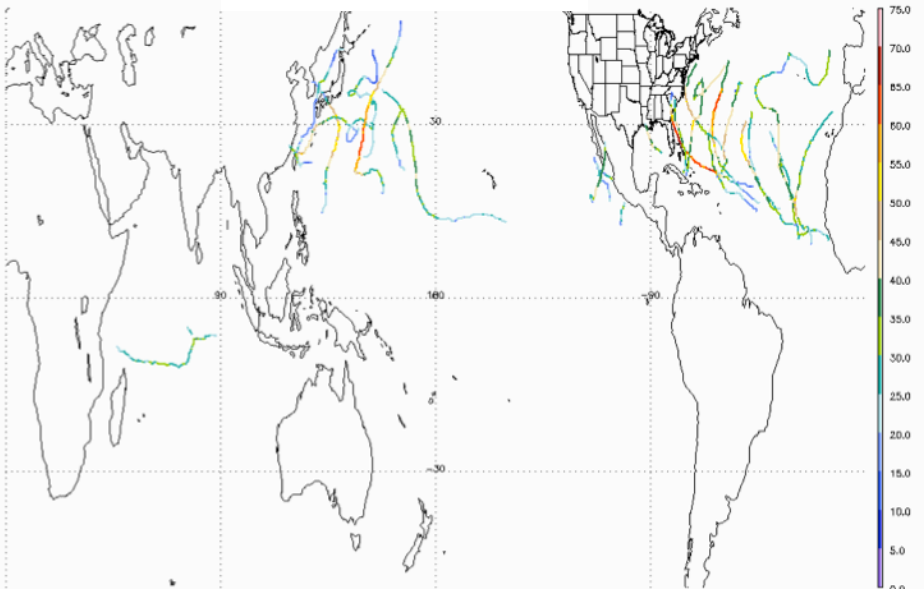
Condensate loading

TC Numbers and Tracks

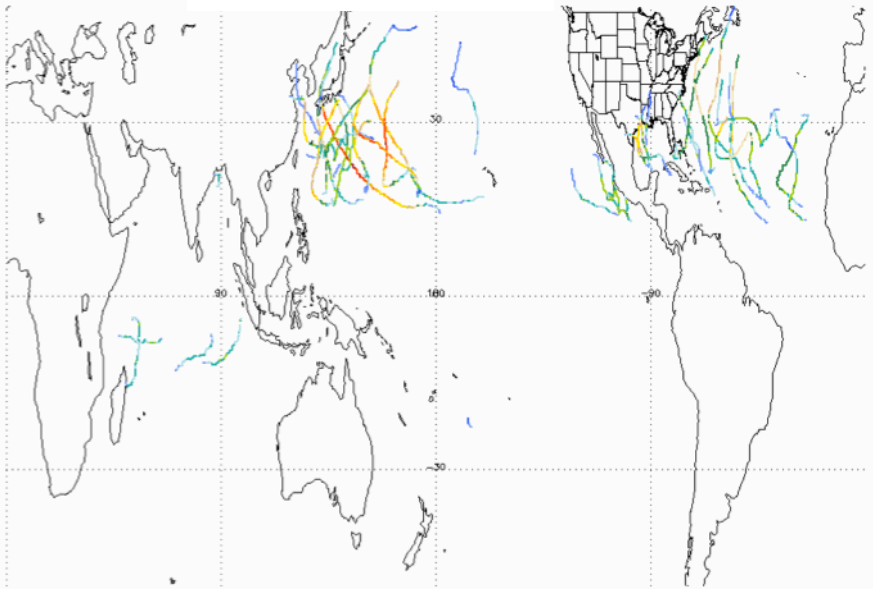
Based on short runs CAM5 roughly captures correct numbers of storms and distinction between active (2005) and and quiet (2006) Atlantic seasons. ***Longer run just completed by DoE shows good statistics 1979-1997 (pers. comm. Michael Wehner)***

Storms with U>33 ms^{-1}: June 1 to Nov 1 2005

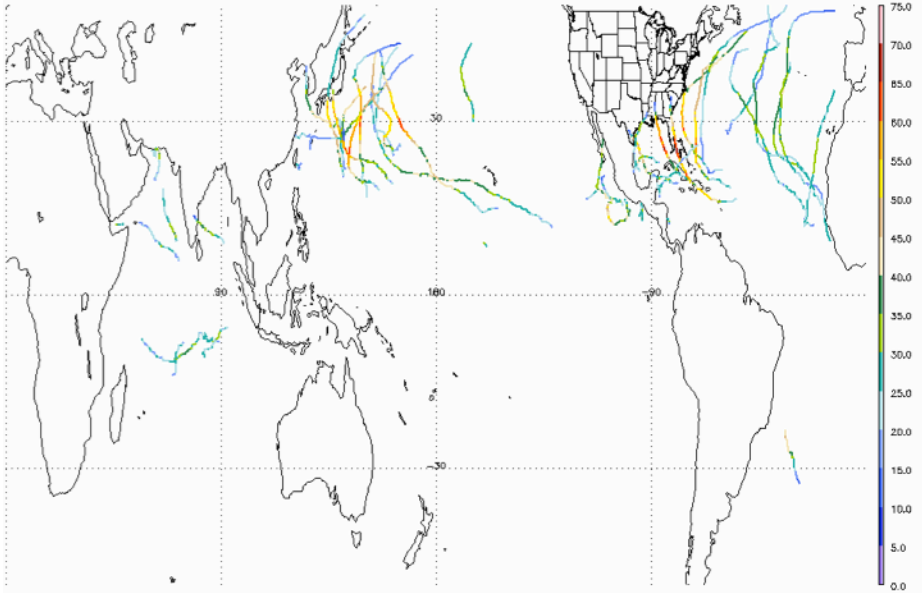
Std CAM5 #1



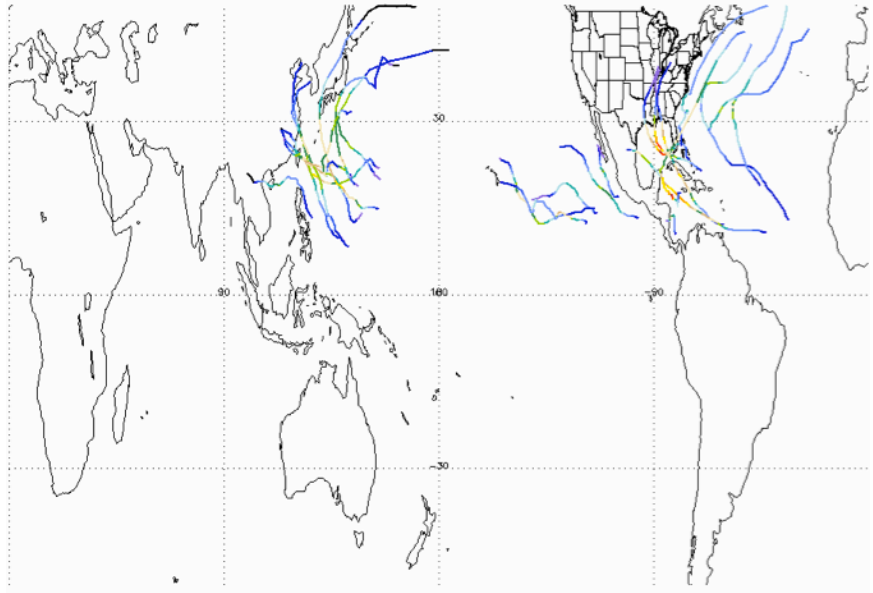
Std CAM5 #2



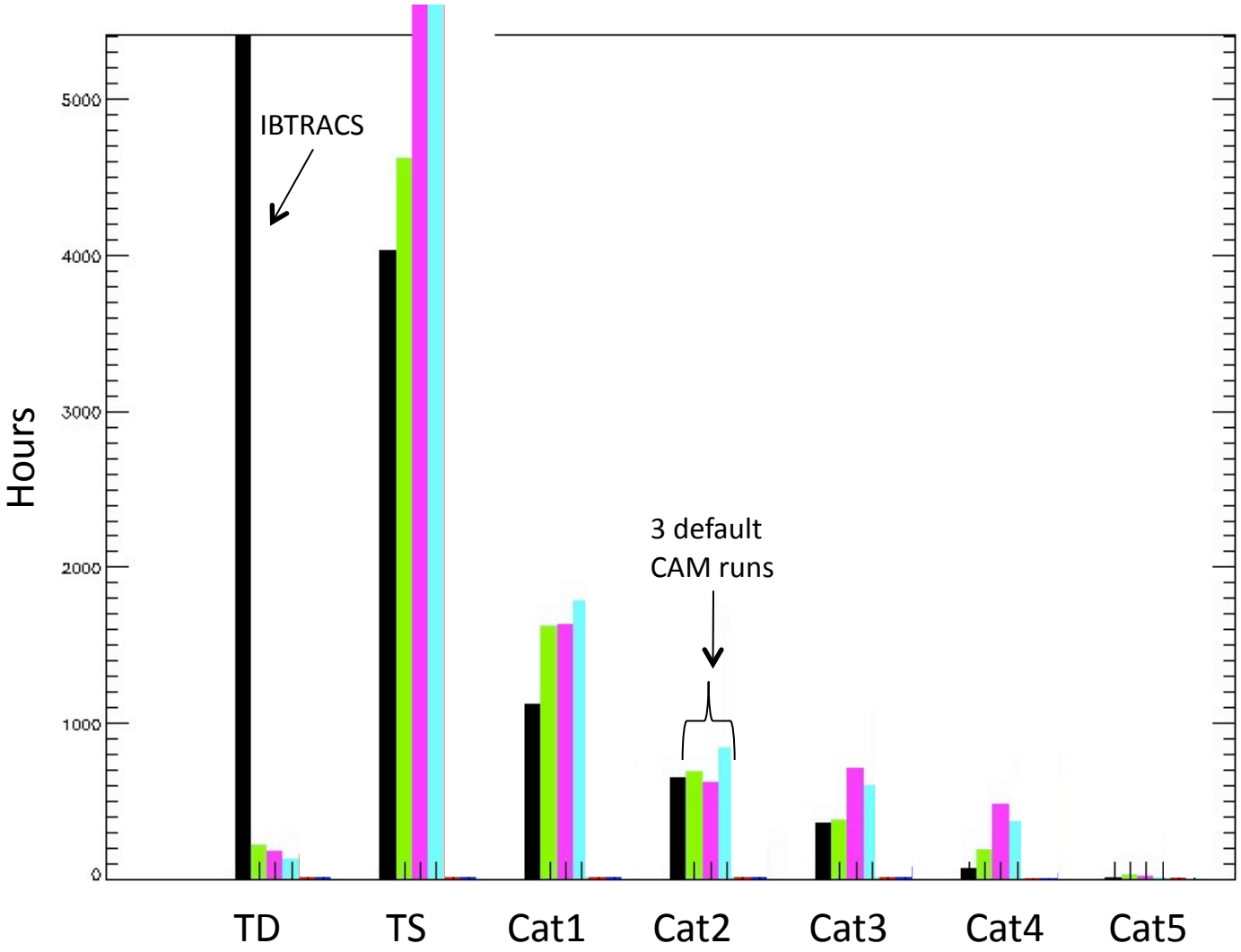
Std CAM5 #3



IBTraCS



Time (hours) spent at Category (CAM5) (June-Nov 2005)



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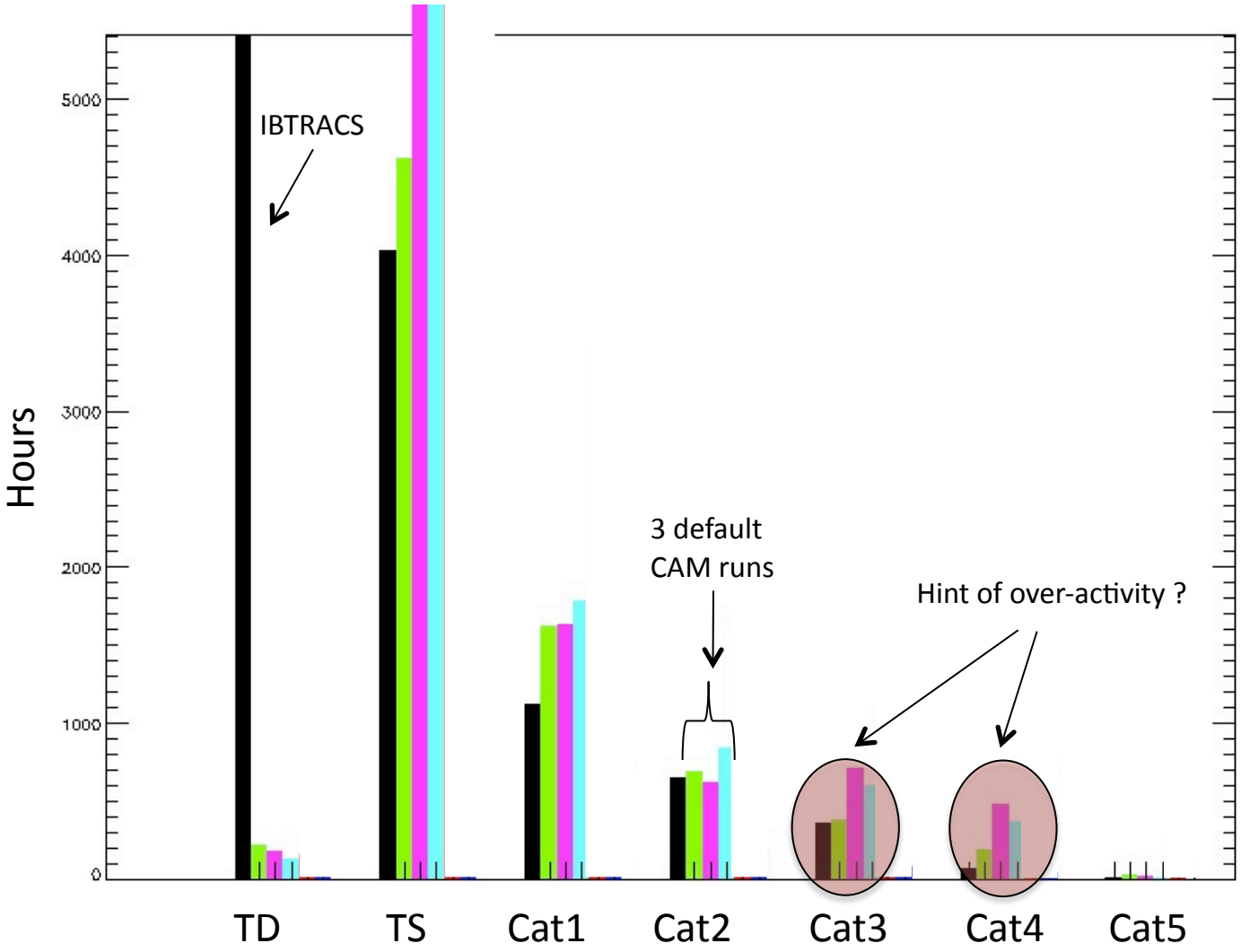
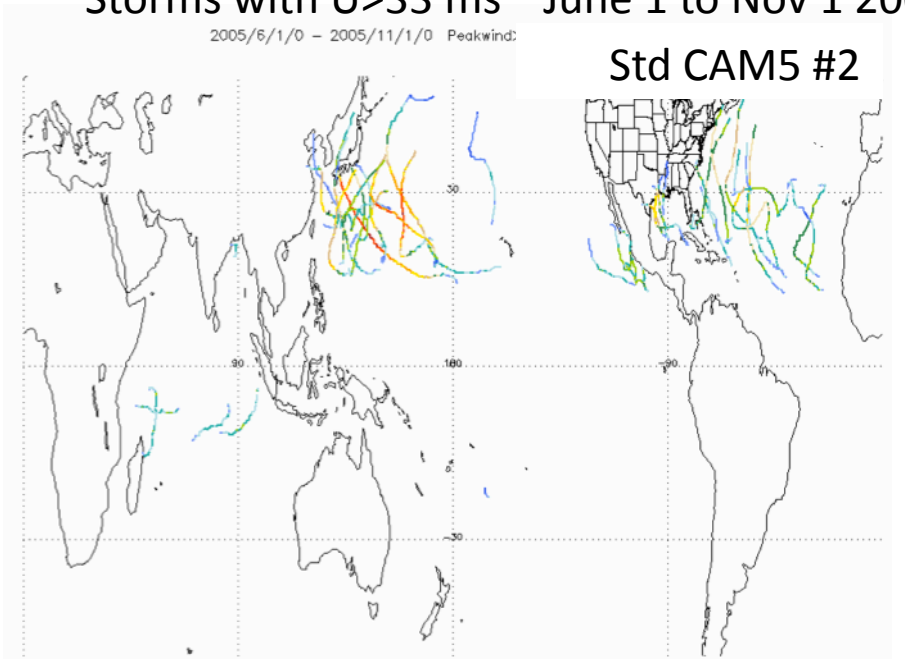


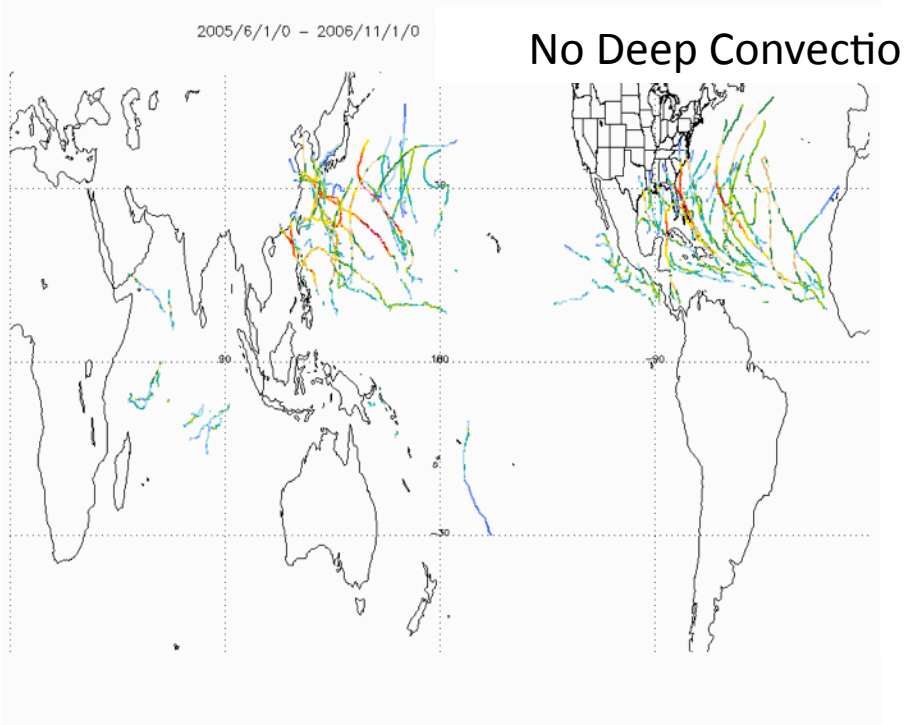
Sensitivity to use of Deep Convection Scheme

GEOS-5 restricts deep convection scheme via entrainment limits.
GFDL eliminates deep scheme (with tuned shallow scheme).
CAM5 precip in TC cores dominated by large-scale.

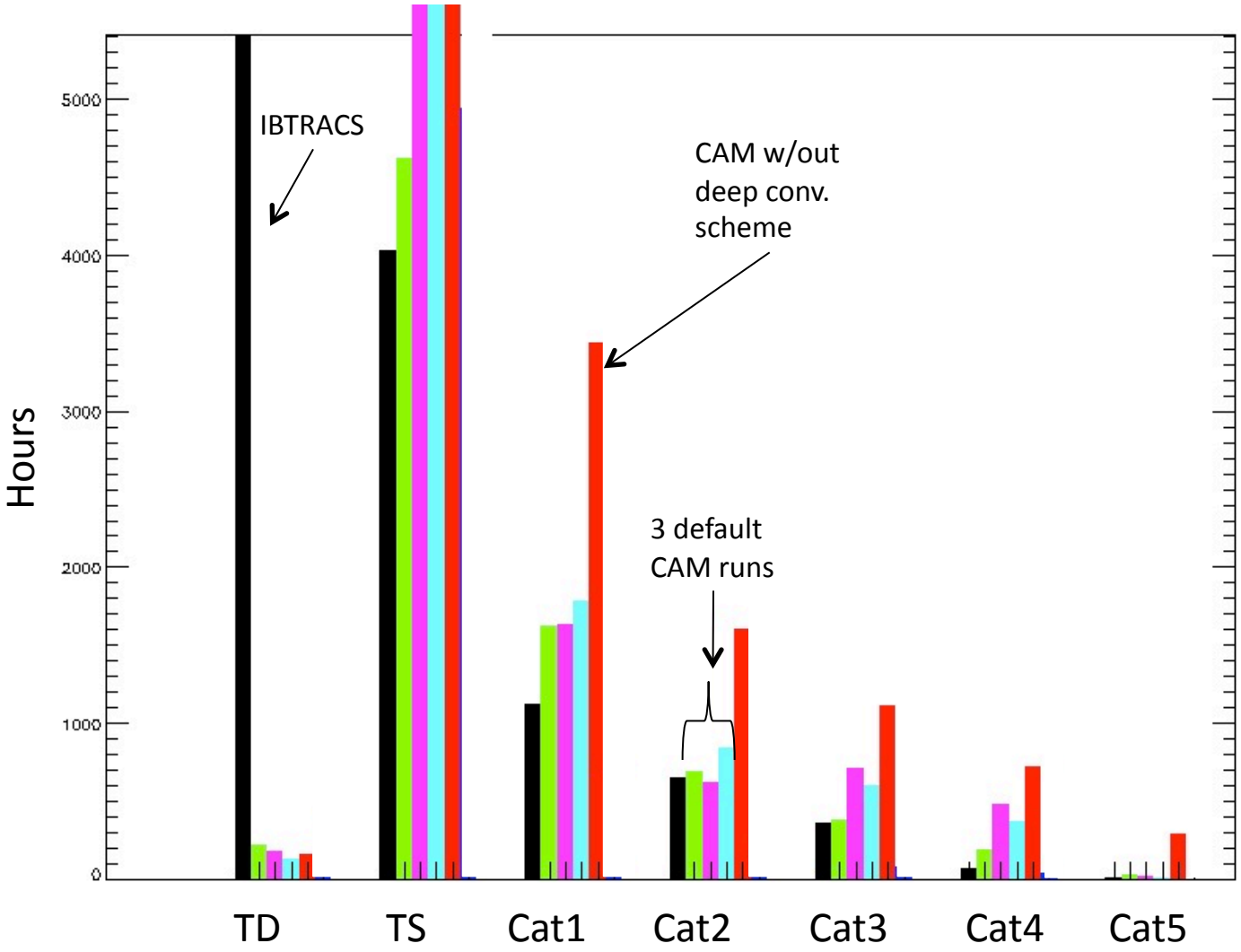
What happens if deep scheme is removed from CAM5?

Storms with U>33 ms^{-1}: June 1 to Nov 1 2005

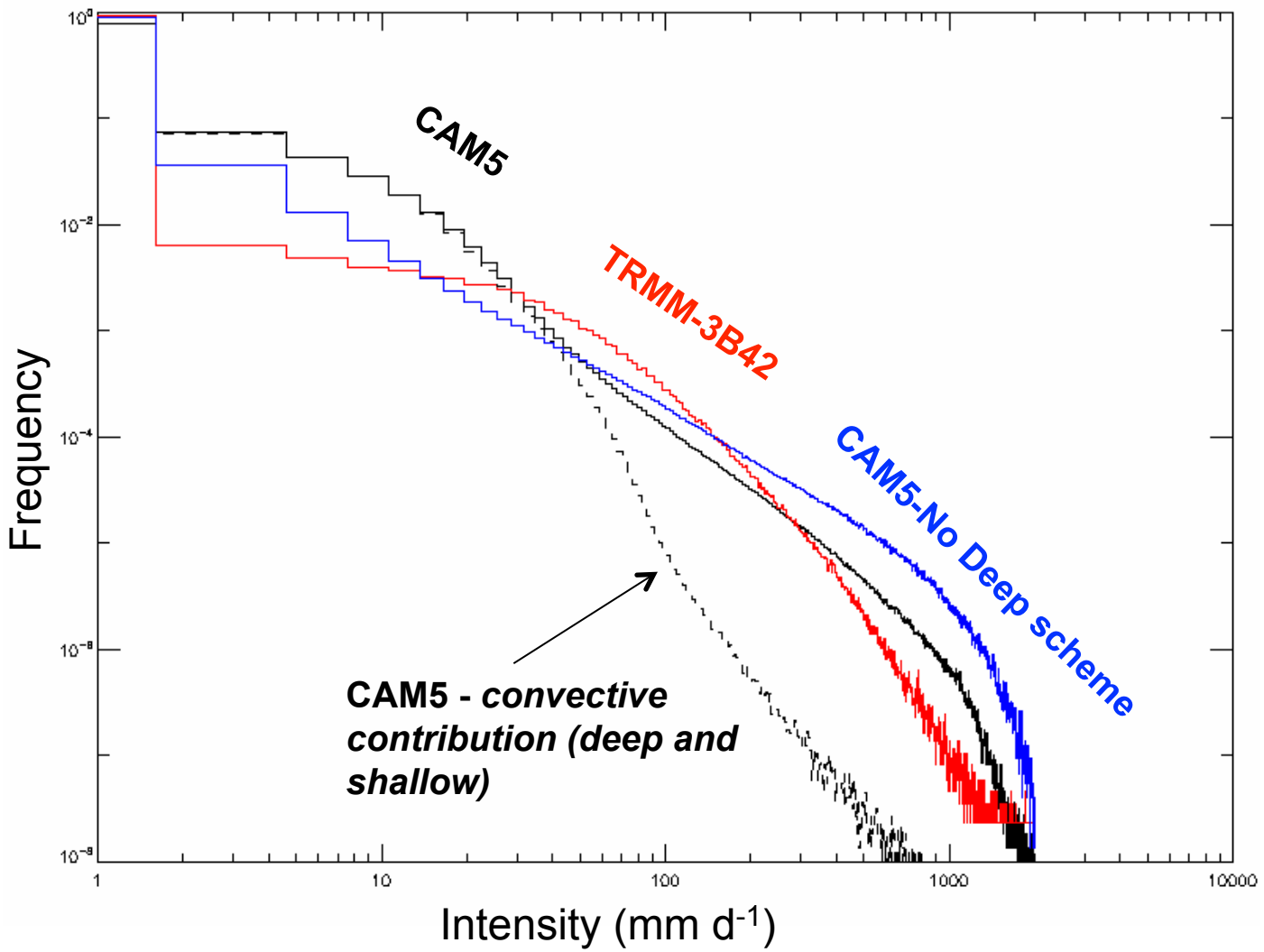




Time (hours) spent at Category (June-Nov 2005)



PDFs of tropical precipitation (30S-30N) rates Aug 2005

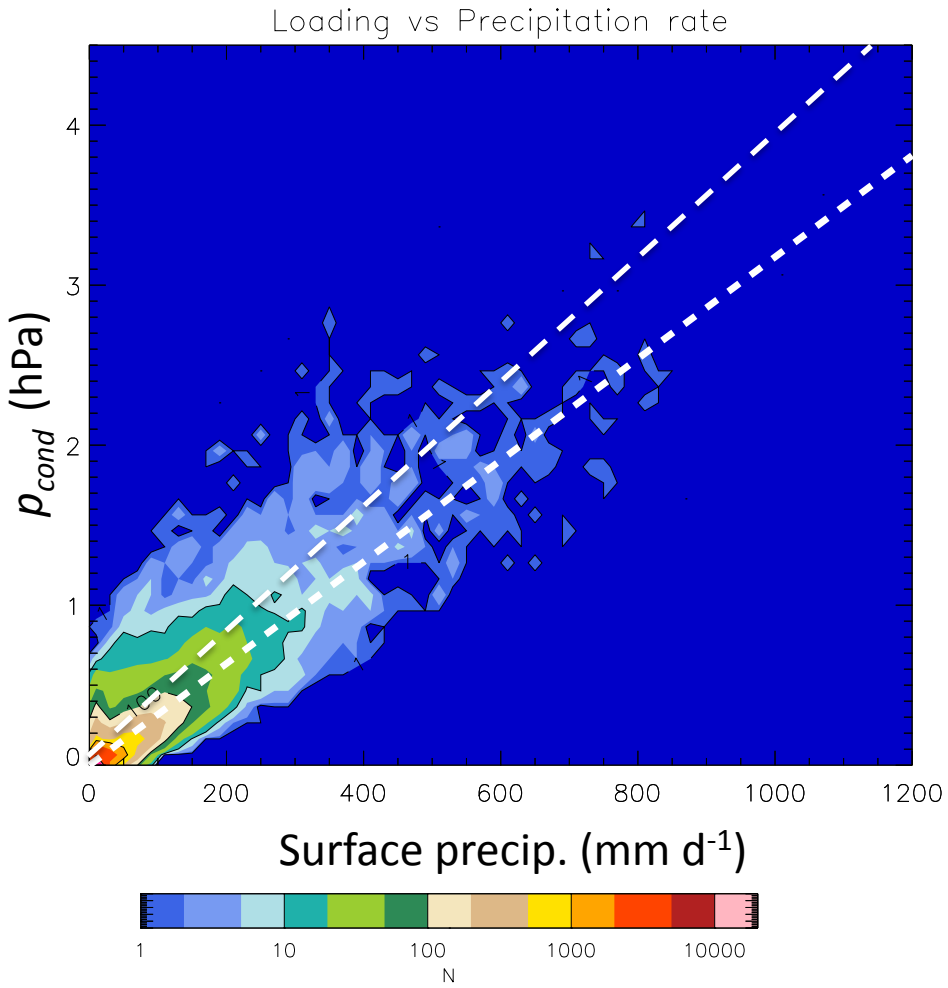


Condensate Loading

Precipitation extremes may be too frequent and extremes are associated with LS condensation (i.e. resolved upward motion aka explicit convection)

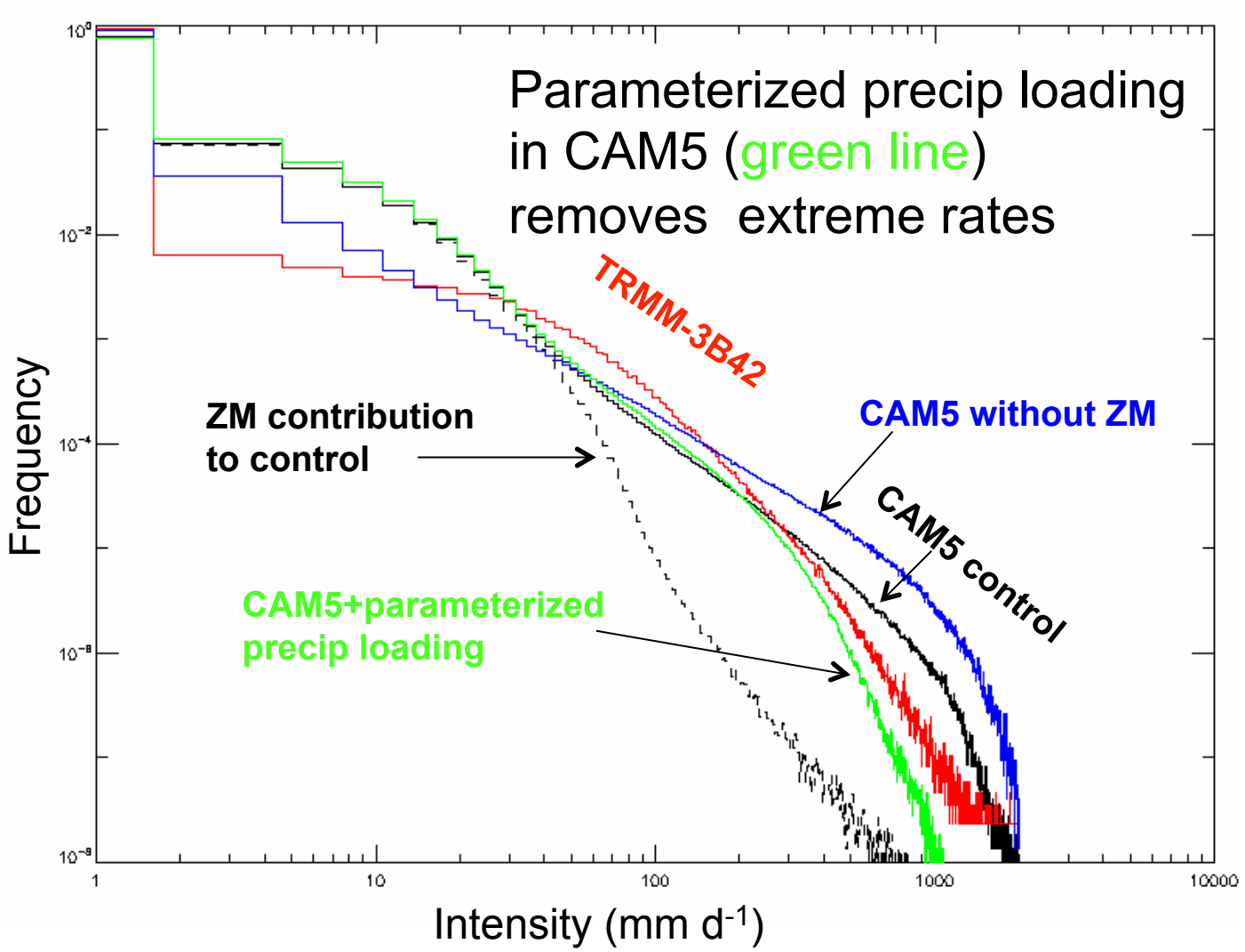
$$p_{cond} = \int_{z}^{z_{top}} g(\rho_l + \rho_i + \rho_r + \rho_s + \rho_{g,h})\, dz'$$ vs Surface precip.

5-day WRF simulation, 500 m resolution, 15-minute output, ***coarse grained to 25km***

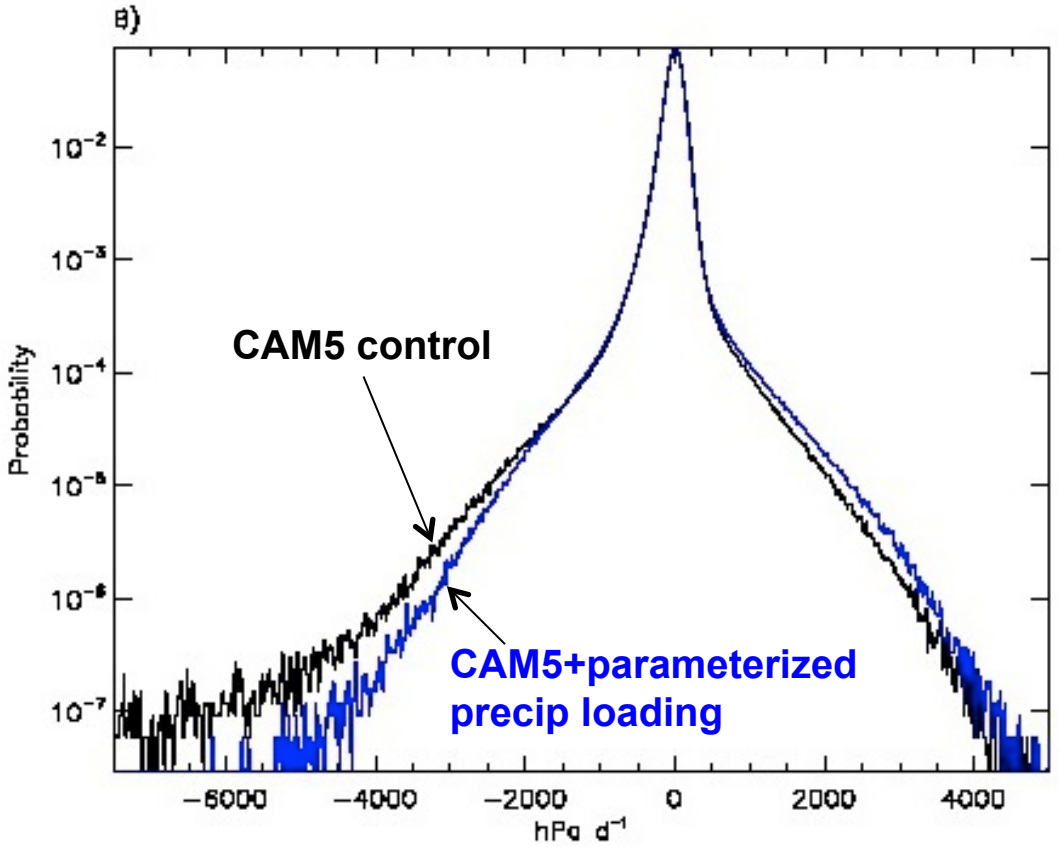


In this WRF simulation, nonhydrostatic effects were small compared to precip loading down to scales ~5 km

PDFs of tropical precipitation (30S-30N) rates Aug 2005
(compiled from 3-hrly instantaneous model output)



PDF of vertical motion at 850 hPa during August 2005

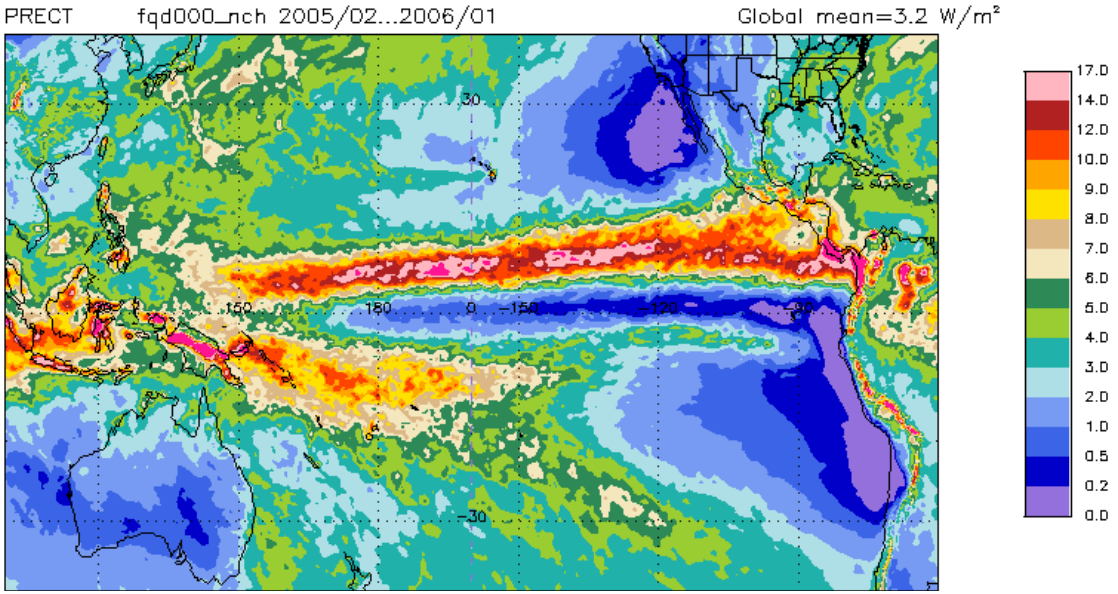


Effects on tropical cyclogenesis are under investigation

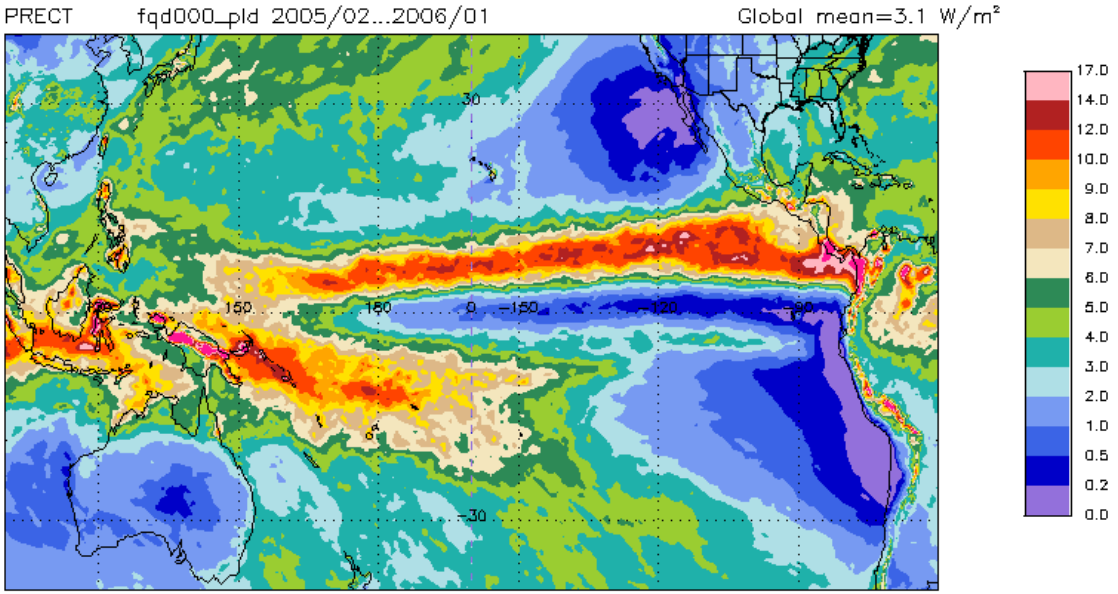
Re-evaporation could multiply direct loading effect by up to ~8x

Annual mean precipitation

CAM5 control



w/ parameterized precipitation loading



Summary

New multi-model project aimed at improving tropical variability high-resolution atmospheric models.

Approach: Coordinated simulations of an individual MJO event during the 2009 Year of Tropical Convection

Some current hypotheses

- Better precipitation dynamics needed – *prognostic treatment, mass included in pressure*